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(54) **Engine blocks.**

(57) A cylinder block (bc) which constitutes a main part of an engine block is formed of a cylinder barrel assembly block (7), a skeleton-like frame surrounding the outer periphery of the cylinder barrel assembly block (7) integrally therewith and a plate-like-rigid film member (9), wherein a fluid passage is disposed in the skeleton-like frame (8). The skeleton-like frame is integrally joined to the outer surfaces of left and right side walls of the assembly block along the axis of a crankshaft and comprises a plurality of crossbeam bone members (15), longitudinal beam bone (16) members and post bone members (17) which have rigidity and are unitarily assembled into a three-dimensional latticework structure. A cylinder head (Hc) is superposed and integrally coupled to the deck surface of the cylinder block (bc) and a lower case is integrally coupled to the lower surface of the cylinder block, lateral outer surfaces of the

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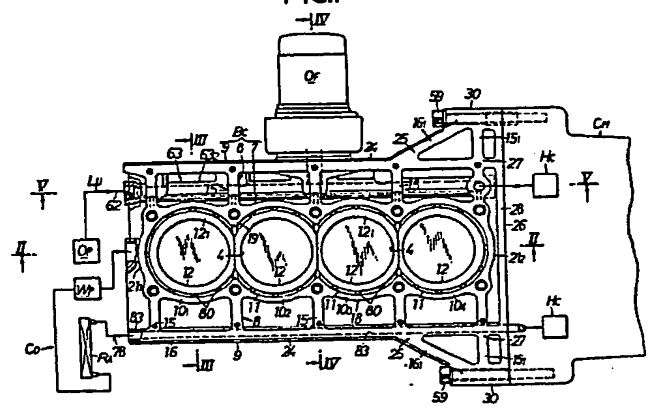
block and lower case along the crankshaft axis being formed flush with each other in parallel with the cylinder bore axis. The lower case (CL) comprises a lower case frame of three-dimensional latticework structure and second rigid film members disposed at least on the lateral outer surfaces of the lower case frame along the crankshaft axis. Moreover, with use of a plurality of oil pan-mounting bolts, the lower case is tightened and secured to the lower surface of the cylinder block and an oil pan (Po) is floatingly carried on the lower surface of the lower case via resilient members. The cylinder block has at its one end surface along the crankshaft axis a square, transmission mating surface and a divergent bulged portion which extends from a rear part of the cylinder block in a fan-shape toward the transmission mating surface. Thereby, the structure of engine block is simplified and vibration and noise of the engine are reduced. The rigidity of engine is enhanced while suppressing the weight increase to a minimum.

FIG.1



ENGINE BLOCKS

The present invention relates to engine blocks.

An engine has been heretofore well known in which vibration proof panels are mounted on a cylinder jacket side member and a crankcase side member to form a rectangular parallelopiped cylinder block so as to reduce noises without lowering the strength of the cylinder block (see Japanese Utility Model Publication No. 43486/1984).

With the recent trend of higher rotation and higher output of the engine, measures for reducing vibrations and noises thereof pose a significant task.

It is considered that the engine gives rise to upper and lower bendings, before and after bendings, torsion or the like, which are synergistically magnified to generate large vibrations and noises. Most vibrations and noises of the engine are propagated to other portions through the cylinder block portion of the engine and the bearing portions of the crankshaft. It is most important to enhance the rigidity of these parts in order to reduce the vibrations and noises. However, in the aforesaid conventional engine, no measure has been taken to enhance the rigidity of the cylinder block portion. In view of the foregoing, it is contemplated that in order to enhance the rigidity of the engine, the engine block which is a vibration generating source, particularly, the cylinder block portion is merely increased in wall thickness, reinforced by a reinforcing member such as a stiffener or formed of a high strength material. This proposal however gives rise to other inconveniences such that the weight of the engine itself is increased, the cost is considerably increased and the like.

An engine block has been known in which measures are taken for enhancing the rigidity of the bearing portion of the crankshaft (see Japanese Patent Publication No. 202349/1983). In this proposal, no measure for fighter weight and lower cost has been taken.

Furthermore, a vehicular engine has been known in which a lower frame is joined to the lower surface of a cylinder block by means of bolts, a crankshaft is rotatably carried between the joined surfaces thereof, and an oil pan is fixedly mounted on the lower surface of the cylinder block by means of other bolts (see U.S. Patent No. 4753201 specification). However, in such an engine as described above, the cylinder block and the lower frame, and the lower frame and the oil pan are respectively directly fixed by separate bolts. A further task arises such that an increase in weight and an increase in cost result due to the increase in the number of bolts, and in addition, since the lower frame and the oil pan are directly fixed, the vibration of the engine during operation is transmitted from the lower frame to the oil pan, and the noise is promoted by the vibration of the oil pan itself.

Furthermore, the vibration of the engine during operation is also transmitted to the joined surface between the cylinder block and the transmission case through the cylinder block. The lack of rigidity of the joined surface causes the vibration and noise to be increased, and therefore the coupling rigidity of the joined surface between the cylinder block and the transmission case is desired to be enhanced as other measure for reducing the vibration and noise of the engine. This conventional proposal has another task in that the aforementioned measure is not satisfactory.

Moreover, in the conventional cylinder block, a solid cylinder barrel wall surrounding a cylinder bore is formed with fluid passages such as a lubricating oil passage, a cooling water passage and the like (see Japanese Patent Publication Nos. 27526/1988 and 37246/1988).

However, in the conventional engines as described above, since there naturally involves a limitation in that the cylinder barrel wall surrounding the cylinder bore is formed with the aforesaid fluid passages, most of the fluid passages are composed of a group of pipes separately from the cylinder block. Therefore, there poses a further task in that not only the number of parts increases to increase the cost but also, since the group of pipes are overhung on the cylinder block, they vibrate to promote the vibration and noise of the engine itself.

Viewed from one aspect the present invention provides an engine block comprising a cylinder block which constitutes a main part of the engine block and is formed of a cylinder barrel assembly block, a skeleton-like frame surrounding the outer periphery of the cylinder barrel assembly block integrally therewith and a plate-like rigid film member provided on the external surface of the skeleton-like frame, wherein a fluid passage is disposed in the skeleton-like frame.

According to another aspect of the invention a cylinder block which constitutes a main part of an engine block is formed of a cylinder barrel asembly block having a plurality of cylinder barrels with a cylinder bore provided thereon, a skeleton-like frame integrally joined to the outer surfaces of left and right side walls of the cylinder barrel assembly block along the axis of a crankshaft, and a plate-like film member integrally provided on the outer surface of the skeleton-like frame, said skeleton-like frame comprising a plurality of crossbeam bone members, longitudinal beam bone members

and post bone members which have rigidity and are unitarity assembled into a three-dimensinal latticework structure.

According to another aspect of the invention there is provided an engine block comprising a cylinder block, a cylinder -head superposed and integrally coupled to the deck surface of the cylinder block and a lower case integrally coupled to the lower surface of the cylinder block, said cylinder block comprising a cylinder barrel assembly block having a plurality of cylinder barrel with a cylinder bore provided, a skeleton frame in the form of a three-dimensional lattice-work structure integrally joined to the outer surfaces of left and right side walls of the assembly block along the axis of a crankshaft and a plate-like rigid film member integrally provided on the left and right outer surfaces of the skeleton-like frame, the cylinder block and the lateral outer surfaces of the lower caee along the crankcase axis being formed flush with each other in parallel with the cylinder bore axis.

Viewed from another aspect the invention, provides an engine block wherein a lower case is integrally joined to the lower surface of a cylinder block having a cylinder barrel in which a piston is slidably fitted, and a crankshaft connected to said piston is rotatably carried between the joined surfaces, said lower case comprising a lower case frame of three-dimensional latticework structure and second rigid film members disposed at least on the lateral outer surfaces of the lower case frame along the crankshaft axis, said lower case frame comprising a plurality of crossbeam bone members having a bearing cap portion of a crankshaft in the central portion thereof and extending laterally in a direction substantially perpendicularly intersecting with the crankshaft axis, a plurality of longitudinal beam bone members for integrally coupling the outer ends of the crossbeam bone members in a direction of the crankshaft axis, and a plurality of post bone members for integrally connecting the outer ends of the crossbeam bone members in a direction of the piston stroke, said second rigid film members being provided on the outer surfaces of the longitudinal bone members and the post bone members.

According to another aspect of the invention there is provided an engine block wherein a lower case is joined to a cylinder block, and a crankshaft is rotatably carried between the joined surfaces, and with use of a plurality of oil pan-mounting bolts, the lower case is tightened and secured to the lower surface of the cylinder block and an oil pan is floatingly carried on the lower surface of the lower case via resilient members.

According to another aspect of the invention there is provided an engine block wherein a cylinder block which constitutes a main part of an engine block is formed of a cylinder barrel assembly block having a plurality of cylinder barrels with a cylinder bore provided thereon, a skeleton-like frame of three-dimensional latticework structure integrally joined to the outer surfaces of left and right side walls of the cylinder barrel assembly block along the axis of a crankshaft, and a plate-like film member integrally provided on the outer surface of the skeleton-like frame, said cylinder block having at its one end surface along the crankshaft axis a square transmission mating surface on the cylinder block side, the left and right side surfaces along the crankshaft axis being linear in the direction of the cylinder bore axis, said cylinder block having a divergent bulged portion which extends from a rear part of the cylinder block in-a fan-shape toward the transmission mating surface on the cylinder block side.

According to the above-described structure, the cylinder block of an engine is formed from the cylinder barrel assembly block, the skeleton-like frame and the rigid film member whereby the bending and torsional rigidity can be enhanced. The skelton-like frame having a function as a strengthening member is utilized to form a fluid passage whereby the whole fluid passage structure can be simplified. The number of parts can be reduced to considerably reduce cost. Furthermore, the overhanging portions from the cylinder block of the fluid passage can be reduced. The rigidity of the engine block itself is enhanced, and vibration and noise of the engine are remarkably reduced.

Furthermore, since the cylinder block which constitutes a vibration source of the engine may be formed so as to have a skeleton-like frame of three-dimensional lattticework structure, the upper and lower and before and after the engine, and the rigidity with respect to the torsion around the crankshaft are considerably enhanced, and the weight of the engine per unit volume is also considerably reduced. In addition, the manufacturing is easy.

In addition, the lower case may be coupled to the lower surface of the cylinder block, and the cylinder block and the lateral outer surfaces of the lower case along the crankshaft axis formed flush with each other in parallel with the cylinder bore axis whereby high rigidity with respect to the upper and lower and before and after bendings acting on the coupled body and the torsion around the crankshaft are secured and at the same time, lighter weight thereof can be achived and the manufacturing cost can be reduced.

Moreover, the lower case comprising a lower case frame of three-dimensional latticework structure and second rigid film members may be joined to the lower surface of the cylinder block whereby

the rigidity of the engine block itself can be considerably enhanced. The crankshaft subjected to an excessively large explosion load of the engine is firmly supported to suppress the bend and torsion of the engine block itself and considerably reduce vibration and noise of the engine. Furthermore, the weight of the lower case per unit volume is extremely low, thus contributing the lighter weight of the engine block. The manufacturing is easy and accomplished at less cost.

Moreover, the cylinder block and the lower case may be integrally coupled by means of a plurality of fastening bolts and oil-pan mounting belts, and the coupled body may have a rectangular parallelopiped shape so as to have high rigidity. Deformation with respect to the upper and lower and before and after bendings and the torsion around the crankshaft is suppressed. If the lower case and the oil pan are fastened to the cylinder block by the oil-pan mounting bolts, its tightening work becomes easy and the number of bolts can be reduced. In addition, the vibration of the coupled body of the cylinder block and the cylinder head is damped and absorbed by a plurality of resilient members to reduce the transmission thereof to the oil pan.

Furthermore, the weight of the entire structure is reduced and the bending and torsional rigidity thereof are considerably enhanced by the skeleton-like frame of three-dimensional latticework structure and the plate-like rigid film member, and at the same time the transmission-case mating surface may be formed into a square shape having a large area, and the coupling strength with the transmission considerably enhanced.

An embodiment of the invention will now be described by way of example and with reference to the accompanying drawings, in which Fig. 1 is a plan view of a cylinder block of the engine taken on line I-I of Fig. 3; Fig. 2 is a partly sectioned side view of an engine block taken on line II-II of Fig. 1; Fig. 3 is a sectional view of the engine block taken on line III-III of Fig. 1; Fig. 4 is a partly enlarged sectional view of the cylinder block taken on line IV-IV of Fig. 1; Fig. 5 is a sectional view of the cylinder block taken on line V-V of Fig. 1; Fig. 6 is a perspective view of the whole structure showing a lubricating system and a cooling system of the engine; Fig. 8 is a bottom view of the cylinder block taken on line VIII-VIII of Fig. 3; Fig. 9 is a plan view of a lower case taken on line IX-IX of Fig. 3; and Fig. 10 is a bottom view of the lower case taken on line X-X of Fig. 3.

Figs. 1 to 4 show an engine block of a series four-cylinder engine. In these Figures, an engine block E of the engine accoording to the present embodiment comprises a cylinder block Bc, a cylinder head Hc joined to the surface of deck 1 through a gasket 2, and a lower case C_L coupled to the lower surface of the cylinder block Bc. A head cover C_H is placed over the upper surface of the cylinder head Hc, and an oil pan Po is joined to the lower surface of the lower case C_L through a packing P. A crankshaft 3 is rotatably carried on the mating surface between the cylinder block Bc and the lower case C_L, and pistons 5 are slidably fitted in cylinder bores 4, respectively, of four first to fourth cylinder barrels 10_1 to 10_4, said pistons 5 and said crankshaft 3 being connected through connecting rods 6.

The construction of the cylinder block Bc will be described hereinafter principally referring to Figs. 1 to 4 as well as Figs. 5, 6 and 8.

Fig. 5 is a longitudinal sectional view taken on line V-V of Fig. 1 of a lubricating oil passage, Fig. 6 is a perspective viw of a skeleton-like frame which will be described later of the engine block E, and Fig. 8 is a bottom view of the cylinder block Bc.

The cylinder block Bc is integrally molded by casting light alloy material such as Fe or Aℓ, Mg alloys except a rigid film member 9 which will be described in detail, the whole cylinder block Bc having a rectangular parallelopiped shape as shown in Fig. 6. The cylinder block Bc is integrally formed from three elements, i.e., a cylinder barrel assembly block 7, a skeleton-like frame 8 and a rigid film member 9 (Fig. 7) so as to have light weight, high strength and high rigidity.

The cylinder barrel assembly block 7 forms the core which constitutes a main strengthening member of the cylinder block Bc and is formed to be a unitary body having four first to fourth cylinder barrels 10_1 to 10_4 arranged in a row. The first to fourth cylinder barrels 10_1 to 10_4 are formed with cylindrical hollow portions 11, respectively, and boundary portions of the hollow portions 11 and 11 adjacent to each other are communicated with each other. A cylinder liner having an outward flange portion 12_1 at the upper end thereof, i.e., a wet liner 12 is inserted and attached to each of the hollow portions 11 to thereby form the cylinder bore 4 having a cylinder axis ℓ_1 to ℓ_1 perpendicular to the first to fourth cylinder barrels 10_1 to 10_4, respectively. Front and rear end walls 21_1 and 21_2 of the cylinder barrel assembly block 7 and adjacent boundary walls 19 of the first to fourth cylinder barrels 10_1 to 10_4 are formed to have a large wall-thickness so that high strength of the cylinder barrel assembly block 7 itself may be secured. The piston 5 is slidably fitted in the cylinder bore 4 of the wet liner12, and a water jacket 13 (Figs. 2 and 3) is formed between the inner peripheral surface of the first to fourth cylinder barrels 10_1 to 10_4 and the wet liners 12. Water from a cooling system Co which will be described later is supplied into the water jacket 13 whereby the first to fourth cylinder

barrels 10_1 to 10_4 and the wet liners 12 are forcibly cooled.

Upper half portions 22 of bearing for carrying upper half portions of journal portion 3_1 of the crankshaft 3 are formed on the lower surfaces of front and rear end walls 21_1 and 21_2 having a large wall-thickness lengthwise of the cylinder barrel assembly block 7 and a boundary wall 19 having a large wall-thickness between the adjacent cylinder bores 4 and 4 of the assembly block 7.

The construction of the skeleton-like frame 8 of three-dimensional latticework structure will be described hereinafter. The skeleton-like frame 8 principally constitutes a strengthening member of the cylinder block Bc and is integrally molded from the same material as that of the assembly block 7 so as to surround the outer periphery of the cylinder barrel assembly block 7. The skeleton-like frame 8 is formed into a generally rectangular parallelopiped configuration by integrally assembling a plurality of crossbeam bone members 15 ...., longitudinal beam bone members 16 ... and post bone members 17 ... into a three-dimensional latticework structure. The construction of these bone members 15 ...., 16 ... and 17 ... will be further described in detail. The plurality of crossbeam bone members 15 having a square in section are integrally stood upright on the outer surfaces of left and right side walls 18 and 18 along the arranging direction (crankshaft axis direction ℓ_1 - ℓ_1) of the cylinder bores 4 of the cylinder barrel assembly block 7 substantially vertically equally spaced apart from the front and rear end walls 21_1, 21_2 and the boundary wall portions 19 of the assembly block 7. The crossbeam bone members 15 are extended laterally to left and right substantially perpendicularly intersecting the crankshaft axis ℓ_2 - ℓ_2 from the cylinder barrel assembly block 7. The lowermost one of the vertically arranged crossbeam bone members 15 is formed so as to have a larger diameter than that of the remaining crossbeam bone members to further enhance rigidity of the lower surface of the cylinder block Bc, that is, the surface joined (a support portion of the crankshaft 3) with the lower case C_1 which will be described later. The longitudinal beam bone members having a square in section and the post bone members 17 in the form of an integral latticework structure which form both side walls lengthwise of the skeleton-like frame 8 are integrally coupled to the outer ends of the plurality of crossbeam bone members 15. The plurality of longitudinal beam bone members 16 extend parallel with each other lengthwise substantially vertically equally spaced apart from the cylinder barrel assembly block 7, and the plurality of post bone members 17 vertically extend parallel with each other substantially equally spaced apart lengthwise of the cylinder barrel assembly block 7.

The skeleton-like frame 8 is formed by assembling the crossbeam bone members 15, longitudinal beam bone members 16 and post bone members 17 into a three-dimensional lattice-work structure whereby high bending and torsional strength despite the light weight are secured.

The crossbeam bone members 15 and the post bone members 17 are aligned on the lateral extension of the both end walls lengthwise of the cylinder barrel assembly block 7 and the boundary walls 19 between the adjacent cylinder bores 4 and 4 of the assembly block 7, and serve as the strengthening members which can effectively withstand the load from the bearing portion of the crankshaft 3 which will be described later. The lateral outer surfaces along the crankshaft axis ℓ_2 - ℓ_2 of the skeleton-like frame 8 composed of the plurality of longitudinal beam bone members 1 and post bone members 17 are formed into straight surfaces substantially parallel with the cylinder bore axis ℓ_1 - ℓ_1 over the full vertical length from the upper end reaching the deck surface 1 of the cylinder block Bc to the lower end reaching the joined surface 23 of the lower case C_L.

As shown in Figs. 1, 6 and 8, left and right outer surfaces 24 and 24 of the skeleton-like frame 8 are integrally formed with left and right bulged portions 25 and 25 divergently enlarged from the rear portion thereof, that is, the outer end portion of the crossbeam bone member 15 positioned at the boundary wall 19 between the third and fourth cylinder barrels 10_3 and 10_4 toward the rear end surface of the skeleton-like frame 8 whereby the rear end surface lengthwise of the skeleton-like frame 8 is formed so as to have a square section larger in area than that of the front end surface. The left and right bulged portions 25 are formed into a triangle pole by extended crossbeam bone members 15_1, 15_1 ... laterally outwardly extended from a crossing portion 27 of left and right crossbeam bone members 15, 15 positioned at the rear end surface of the skeleton-like frame 8, that is, on the transmission mating surface 26 side on the cylinder block side, longitudinal beam bone members 16, 16 and post bone members 17, 17, diagonally rearwardly extending inclined longitudinal beam bone members 16_1, 16_1 ... branched from a portion corresponding to the boundary wall 19 between the third and fourth cylinder barrels 10_3 and 10_4 of the longitudinal beam bone members 16, 16 ...., and vertically extending outer post bone members 17_1 17_1 by integrally connecting the outer ends of the extended crossbeam bone members 15_1, 15_1 ... and inclined longitudinal beam bone members 16_1, 16_1 ... The inclined outer surfaces of the left and right bulged portions 25 and 25 in the form of a triangle pole are formed to be linear

parallel to the vertical direction, that is, the cylinder bore axis ℓ_1 - ℓ_1 direction.

The left and right bulged portions 25 and 25 are integrally formed at the rear suface thereof with a transmission case mounting frame 28 having the same shape as the former. The frame 28 has a lower surface opened gate shape formed by a lateral frame 28_1 and left and right longitudinal frames 28_2 and 28_2, and the rear surface thereof is formed on the transmission mating surface 26 on the cylinder block side.

As described above, the transmission mating surface 26 on the cylinder block side at the rear end surface of the cylinder block Bc has a square shape, and a lateral span thereof perpendicularly intersecting with the crankshaft axis ℓ_2 - ℓ_2 is enlarged to enhance the bending and torsinal rigidity of the transmission mating surface 26.

Upper edge corners of the left and right bulged portions 25 and 25 are integrally provided before and after with tubular upper bolt inserting bosses 30 and 30 for mounting the transmission case C_M.

As shown in Figs. 4 and 7, left and right rigid film members 9 and 9 each comprising a single plate of metal plate such as steel plate, aluminum plate, etc. or reinforced synthetic resin plate such as FRP, FRM, etc. are directly adhered to linear left and right outer surfaces 24 and 24 extending vertically along the cylinder bore axis ℓ_1 - ℓ_1 of the skeleton-like frame 8, by an adhesive.

As the aforesaid adhesive, FM-300 (manufactured by American Cyanamid) containing a heat resistant epoxy group resin as a main component is used. The rear portions of the rigid film members 9 and 9 are outwardly bended so that they may be disposed along the left and right outer surfaces of the skeleton-like frame 8 as shown in Fig. 7.

The left and right outer surfaces 24 and 24 of the skeleton-like frame 8 are formed into the vertical straight surfaces whereby the rigid film members 9 and 9 can be also formed by plates each having a vertical straight surface, facilitating the manufacture thereof as high rigid material and damping material. Since the rigid film member 9 is linear substantially parallel with the cylinder bore axis ℓ_1 - ℓ_1, it receives, principally as a shearing stress, bending acting on the cylinder block Bc and torsional vibration around the crankshaft 3.

It is noted that the rigid film member 9 may be molded by casting or the like integrally with the skeleton-like frame 8. Further, the rigid film member 9 may be divided into two front and reach sheets at the bended portion on the outer surface of the skeleton-like frame 8, that is, at the base end of the bulged portion 25. In this way, the divided rigid film members 9 can be formed from a single flat plate to further facilitate the manufacture thereof.

As shown in Fig. 4, the lower case C_L is fixedly mounted on the lower surface of the cylinder block Bc by means of a plurality of connecting bolts 32 and oil panmounting bolts 33.

The construction of the lower case C_L will be described hereinafter with reference to Figs. 1 to 4, 6, 7, 9 and 10. The lower case C_L comprises a lower case frame 34 of which planar shape is a three-dimensional latticework structure having the substantially same shape as the planar shape of the cylinder block Bc, two rigid film members 35 and 35 directly adhered to both left and right sides along the lengthwise (the crankshaft axis ℓ_2 - ℓ_2 direction) of the lower case frame 34, and a bottom plate having rigidity which also serves as a baffle plate adhered to the bottom surface of the lower case frame 34.

The lower case frame 34 is constituted by assembling and connecting a plurality of crossbeam bone members 37, longitudinal beam bone members 38 and post bone members 39 into a three-dimensional latticework structure likewise the skeleton-like frame 8 of the cylinder block Bc. The plurality of crossbeam bone members 37 are laterally arranged in upper and lower two rows in a spaced relation lengthwise -(crankshaft axis ℓ_2 - ℓ_2 direction) of the lower case C_L, and the plurality of longitudinal beam bone members 38 and post bone members 39 are integrally coupled to both the left and right ends of the crossbeam bone members 37 longitudinally and vertically of the lower case C_L. When the cylinder block Bc is coupled onto the lower case C_L, the crossbeam bone members 37, longitudinal beam bone members 38 and post bone members 39 of the lower case C_L are vertically placed in registration with the crossbeam bone members 15, longitudinal beam bone members 16 and post bone members 17 of the cylinder block B_C whereby the coupled body of the cylinder block Bc and lower case C_L is formed into a rectangular parallelopiped shape in which both front and rear ends and left and right sides of the engine block E are vertically straight.

Intermediate portions of the upper and lower crossbeam bone members 37 of the lower case C_L are integrally joined by a pair of reinforcing posts 40 and 40 vertically extending in a spaced relation to left and right. Each of the crossbeam bone members 37 is formed, between the reinforcing posts 40 and 40, a semicircular lower half portion of bearing for carrying the lower half portion the crankshaft 3, that is, a bearing cap portion 42.

As shown in Figs. 3 and 4, when the cylinder block Bc is coupled to the lower case C_L, the pair of reinforcing posts 40 and 40 are vertically placed in registration with the front and rear end walls 21_1, 21_2 having a large wall-thickness and boundary

walls 19 of the cylinder barrel assembly block 7 of the cylinder block Bc, and the bearing cap portions 42 are placed in registration with the upper half portions 22 of bearing on the lower surface of the cylinder block Bc to constitute a plurality of bearing portions b of the crankshaft 3. A journal portion 3_1 of the crankshaft 3 is rotatably carried by the bearing portions b through bearing metal 43 as shown in Figs. 2 to 4.

The rear portions of both outer surfaces lengthwise of the lower case C_L are integrally formed with bulged portions 45 divergently spread outwardly toward the rear ends thereof. The front end (the end on the transmission mounting side) of the lower case C_L is formed to be wider than the front end thereof by said bulged portion 45, and the wide rear end is formed with a transmission mating surface 46 on the lower case side of which end shape is in the form of a depression. The transmission mating surface 46 cooperates with the transmission mating surface 26 on the cylinder block side of the cylinder block Bc to form a square-shaped transmission mating surface f, to which is coupled the transmission case C_M as shown in Fig. 1.

The bulged portion 45 comprises an extended lateral beam bone member 37_1 extending from a lateral beam bone member 37 at the rearmost end, an inclined longitudinal beam bone member 38_1 branched from the rear portion of the longitudinal beam bone member 38 and coupled to the outer end of the extended lateral beam bone member 37_1, and a post bone member 39_1 for vertically connecting outer ends of the extended lateral beam bone members 37_1 37_1 and longitudinal beam bone members 38_1 38_1. The left and right bulged portions 45 are formed at left and right corners at the lower edges thereof with lower bolt inserting bosses 47 for coupling the transmission case C_M to the lower case C_L. As shown in Figs. 2 to 4, when the cylinder block Bc and the lower case C_L are connected together, the bulged portion 45 of the lower case C_L is formed flush with the outer surface of the bulged portion 45, and their rear ends are formed into a square shape of which outer peripheral edges are registered, the end thereof being formed with a transmission mating surface f. Lower bolt inserting bosses 30, 30, 47 and 47 are disposed at four corners of the transmission mating surface f. The joined surface of the transmission case C_M is superposed to the transmission mating surface f, which are integrally connected by threadedly applying four connecting bolts 59 inserted into the bolt inserting bosses 30, 30, 47 and 47 to the transmission case C_M. As just mentioned above, the connected body of the cylinder block Bc and lower case C_L and the transmission case C_M can be coupled to each other by only four connecting bolts 59. The coupling work is easy, contributing to lighter weight of the whole structure.

As shown in Figs. 3, 4 and 7, rigid film members 35 and 35 formed from a single plate of metal plates cuch as a steel plate, an aluminum plate, etc. and strengthened synthetic resin plates such as FRP, FRM, etc. are directly adhered by an adhesive to both left and right outer surfaces formed from vertically straight surfaces of the lower case 34. The rigid film members 35 and 35 are formed flush with the left and right rigid film members 9 and 9 of the cylinder block Bc.

It is noted that the rigid film member 35 may be molded by casting or the like integrally with the lower case frame 34. It is further noted that the rigid film member 35 may be divided into two front and rear sheets at the bended portion of the left and right outer surfaces of the lower case frame 34, that is, at the base end of the bulged portion 45. In this way, the divided rigid film members 35 can be formed from a single flat plate, further facilitating the manufacture thereof.

As shown in Figs. 2 to 4, a bottom plate 36 as a baffle plate formed from a flat plate such as a metal plate, a plastic plate, etc. is joined by an adhesive to the flat bottom surface of the lower case C_L, and an oil pan Po is coupled to the lower surface of the bottom plate 36. The bottom plate 36 is bored with a plurality of oil return holes 50 as shown in Figs. 3, 7 and 10 so that lubricating oil may flow between the cylinder block Bc and the oil pan Po through the oil holes 50.

It is noted that the bottom plate 36 may be divided into a plurality of plates.

As shown in Figs. 2 to 4, the flat upper surface of the lower case C_L composed of the lower case frame 34, left and right rigid film members 35, 35 and bottom plate 36 is superposed to the flat bottom surface of the rectangular parallelopiped cylinder block Bc, and the cylinder block Bc and the lower case C_L are integrally connected by threadedly applying a plurality of connecting bolts 32 inserted into the lower case C_L to the cylinder block Bc from the lower surface of the lower case C_L. As shown in Figs. 4, 8 and 9, the mating surface of the cylinder block Bc and the lower case C_L is provided with locating collars C for locating them, said connecting bolts 32 extending through the collars C.

The oil pan Po is superposed to the flat lower surface of the lower case C_L, and the oil pan Po along with the lower case C_L are secured together to the cylinder block Bc by means of a plurality of oil pan-mounting bolts 33. The mode of securing the oil pan Po and the lower case C_L to the cylinder block Bc will be described in detail with reference to Figs. 4 and 10. A large diameter portion 33_1 of a head of the oil pan-mounting bolt

33 extends through a mounting hole 29a bored in a mounting flange 29 in the outer periphery of the oil pan Po through a resilient gromet 31 as a resilient member formed of rubber, synthetic resin or the like, and a shaft portion 33_2 thereof extends through the lower case C_L and is threadedly mounted to the cylinder block, as shown in Fig. 4. As shown in Fig. 2, the rear end (right end) of the oil pan Po is secured to the rear end of the lower case C_L by means of a short bolt 41 through the resilient gromet 31.

With the above-described arrangement, the oil pan Po is floatingly carried on the lower surface of the lower case C_L by the oil pan-mounting bolt 33 through the resilient gromet 31 so that vibration from the lower case C_L is not easily transmitted to the oil pan Po. Moreover, since the lower case C_L and the oil pan Po are tightened together to the cylinder block Bc by the oil pan-mounting bolts, not only the tightening work is simplified but also the number of bolts can be reduced.

Incidentally, the oil pan Po can be formed of any desired kind of material. The above floating structure is, however, extremely effective when the oil pan is made of a resin material such as the kind of polyamide resin, in order to prevent concentration of the tightening force of the mounting bolts 33. This floating structure is also effective when the oil pan Po is made of a sheet metal.

The cylinder block Bc and the lower case C_L are connected whereby the bearing portion b is formed in the mating surface therebetween, and the journal portion 3_1 of the crankshaft 3 is rotatably carried on the bearing portion b through the bearing metal 43.

As shown in Figs. 1 to 4, the cylinder head Hc is integrally coupled to the flat deck surface 1 of the cylinder block Bc by a plurality of long and short connecting bolts 51 and 52. As shown in Fig. 3, outer surfaces S_2, S_2 lengthwise of the cylinder head Hc, that is, along the crankshaft direction ℓ_2 - ℓ_2 are positioned inwardly of the extended surfaces of outer surfaces S_1, S_1 in the same direction of the cylinder block Bc and the lower case C_L.

Next, a lubricating system Lu provided on the engine block E to forcibly supply lubricating oil to parts to be lubricated of the engine block E will be described with reference to Figs. 1 to 6. As clearly shown in Fig. 6, an oil pump Op is directly connected to one end of the crankshaft 3 opposit the transmission case C_M. An intake port of the oil pump Op is connected through an intake passage 60 to an oil strainer 61 dipped into lubricating oil within an oil pan Po, and a discharge port of the oil pump Op is communicated through a discharge passage 62 with an oil gallery 63 provided within the skeleton-like frame 8 of the cylinder block Bc. The oil gallery 63 is integrally provided within the skeleton-like frame 8 as clearly shown in Fig. 5.

The oil gallery 63 consists of a first and a second oil galleries 63_1 and 63_2. The first oil gallery 63_1 extends lengthwise from one end of the skeleton-like frame 8 to the central portion thereof, the first oil gallery having an outer end to which is opened an inlet 64 in communication with the discharge passage 62 and an inner end to which is opened an outlet 66 in communication with an inlet of an oil filter O_F which will be described later. The second oil gallery 63_2 extends substantially parallel with the first oil gallery 63_1 over the full length of the skeleton-like frame 8 and extends upward while being bended substantially at right angles from the rear end thereof, and an outlet 65 reaching the upper surface of the skeleton-like frame 8 is opened to the upper end thereof. The outlet 65 is communicated with a lubricating-oil passage on the side of the cylinder head Hc not shown. An inlet 67 in communication with an outlet of an oil filter O_F which will be described later is opened to the central portion of the second gallery 63_2. On both left and right sides of the inlet 67, a plurality of oil port 68 are opened in the second oil gallery 63_2 in a spaced relation, the oil ports 68 being communicated with parts to be lubricated formed in the cylinder block Bc, the oil ports 68 being communicated with the bearing portion b of the crankshaft 3 through an oil passage 69 as shown in Fig. 4.

The oil gallery 63 composed of the first and second galleries 63_1 and 63_2 formed integral with the skeleton-like frame 8 whereby it functions as a strengthening member for the skeleton-like frame 8.

As shown in Figs. 1 to 3 and 6, the oil filter O_F is threadedly supported on the outer surface of the skeleton-like frame 8 of the cylinder block Bc, the oil filter O_F having an inlet and an outlet communicated with an outlet 66 of the first oil gallery 63_1 and an inlet of the second oil gallery 63_2, respectively.

When the engine is driven to rotate the crankshaft 3, the oil pump O_F is driven so that lubricating oil within the oil pan Po passes through the oil strainer 61 and is then pumped up by the oil pump O_P. The pressurized lubricating oil from the oil pump Op is introduced into the first oil gallery 63_1 as indicated by arrows in Figs. 5 and 6 through the discharge passage 62. The lubricating oil flowing through the first oil gallery 63_1 flows into the oil filter O_F from the outlet 66 thereof. The lubricating oil cleaned by the oil filter O_F flows into the second oil gallery 63_2, and a part thereof passes through the oil ports 68 and is supplied to a plurality of parts to be lubricated such as the bearing portion of the crankshaft 3 of the cylinder block Bc. The lubricating oil flowing through the second oil gallery 63_2 flows from the outlet 65 to an oil passage not

shown on the side of the cylinder head Hc. The oil gallery 63 composed of the first and second oil galleries 63_1 and 63_2 is formed integral with the skeleton-like frame 8 to serve as a strengthening member for the skeleton-like frame 8.

It is noted that the oil gallery 63 may be formed on the bone members itself which constitute the skeleton-like frame 8.

Next, the construction of a cooling system Co provided on the cylinder block Bc to cool heated parts around the cylinder bores 4 of the cylinder block Bc and the like will be described with reference to principally Figs. 1 and 6. A water pump Wp is supported on the front end wall of the cylinder block Bc, and a pump shaft 70 of the water pump Wp is operatively connected to a timing transmission belt 7 of a timing transmission mechanism T_1 for operatively connecting the crankshaft 3 with a pair of cam shafts 71 and 72. An intake port of the water pump Wp is communicated with an outlet 77 of a radiator R_A through an intake passage 74, and an discharge port thereof is communicated with an inlet 76 of the radiator R_A passing a discharge passage 75, a group of cooling-water passages formed in the cylinder block Bc and cylinder head Hc and a circulating passage 78. A front end wall 21_1 of the cylinder barrel assembly block 7 is bored with an inlet 79 in communication with the water jacket 13 formed therein, the inlet 79 being communicated with a discharge passage 75 in communication with a discharge port of the water pump Wp. An outlet 80 of the water jacket 13 is opened to the deck surface 1 of the cylinder block Bc as shown in Figs. 1, 3 and 6, the outlet 80 being communicated with the water jacket 81 on the side of the cylinder head Hc. The water jacket 81 has an outlet 82 opened to the rear end wall of the cylinder head Hc as shown in Fig. 6, the outlet 82 being communicated with the inlet 76 of the radiator R_A through the circulating passage 78.

One longitudinal beam bone member 16 on the upper edge of the skeleton-like frame 8 of the cylinder block Bc is formed with a straight cooling-water passage 83 over the full length thereof, the passage 83 constituting a part of the circulating passage 78 which communicates wthe water jacket 81 on the side of the cylinder head Hc with the radiator R_A.

When the engine is operated, the water pump Wp is driven through the timing transmission mechanism T_1. Thereby, the cooling water cooled by the radiator R_A is sucked and pressurized by the water pump Wp, passes through the discharge passage 75 and flows into the water jacket 13 formed in the cylinder barrel assembly block 7 of the cylinder block Bc from the inlet 79. The cooling water cools the heated parts around the cylinder bore 4 of the assembly block 7 and thereafter passes through the outlet 80 and flows into the water jacket 81 of the cylinder head Hc to cool the heated parts around the combustion chamber 53 of the cylinder head Hc, after which the cooling water returns to the radiator R_A through the circulating passage 78. At that time, the cooling water flows through a cooling water passage 83 within the longitudinal beam bone members 16 of the skeleton-like frame 8 which constitutes a part of the circulating passage 78.

In Fig. 3, reference numerals 54 and 55 designate intake and exhaust ports, respectively, formed in the cylinder head Hc, and 56 and 57 intake and exhaust valves, respectively, for opening and closing the ports 54 and 55.

While in the above-described embodiment, description has been made of the case where the present invention is applied to a series four-cylinder engine, it is to be noted of course that the invention can be applied to other types of the engine.

It is further noted that other lubricating fluid in place of the lubricating oil may be used in the lubricating system Lu, and that other coolants in place of cooling water may be used in the cooling system Co.

It will thus be seen that the present invention, at least in its preferred forms, provides an engine block which is intended for simplification of the structure resulting from reduction in number of parts and reduction in vibrations and noises of the engine; and furthermore provides an engine block which is designed to enhance a rigidity to the maximum while suppressing an increase in weight of the engine to the minimum by cooperation between a skelton-like frame which principally has a function as a strengthening member and a rigid film member which principally has a function as a rigid member; and furthermore provides an engine block which is designed to achieve lighter weight and lower cost of the engine block while considerably enhancing the rigidity of the engine block, particularly the bearing portions of a crankshaft thereof; and furthermore provides an engine block which is designed to reduce the number of mounting bolts for mounting a lower case and an oil pan to a cylinder block to suppress an increase in weight and an increase in cost of the engine and reduce noises caused by vibrations of the oil pan.

It is to be clearly understood that there are no particular features of the foregoing specification, or of any claims appended hereto, which are at present regarded as being essential to the performance of the present invention, and that any one or more of such features or combinations thereof may therefore be included in, added to, omitted from or deleted from any of such claims if and

when amended during the prosecution of this application or in the filing or prosecution of any divisional application based thereon. Furthermore the manner in which any of such features of the specification or claims are described or defined may be amended, broadened or otherwise modified in any manner which falls within the knowledge of a person skilled in the relevant art, for example so as to encompass, either implicitly or explicitly, equivalents or generalisations thereof.

Claims

1. An engine block comprising a cylinder block which constitutes a main part of the engine block, said cylinder block being formed of a cylinder barrel assembly block, a skeleton-like frame surrounding the outer periphery of the cylinder barrel assembly block integrally therewith, and a plate-like rigid film member provided on the outer surface of said skeleton-like frame, wherein a fluid passage is disposed in the skeleton-like frame.

2. An engine block according to claim 1, wherein said skeleton-like frame has bone members which are assembled into a three-dimensional latticework structure, and a part of said bone members is formed in said fluid passage.

3. An engine block according to claim 1, wherein said skeleton-like frame has bone members which are assembled into a three-dimensional latticework structure, and a fluid passage is formed in at least a part of a reinforcing member for reinforcing said skeleton-like frame.

4. An engine block according to claim 1, 2 or 3, wherein said fluid passage comprises an oil gallery through which flows lubricating oil for lubricating parts to be lubricated of the engine.

5. An engine block according to claim 1, 2 or 3, wherein said fluid passage comprises a passage through which flows cooling water for cooling heated parts of the engine.

6. An engine block comprising a cylinder block which constitutes a main part of the engine block, said cylinder block comprising a cylinder barrel assembly block provided with a plurality of cylinder barrels each having a cylinder bore, a skeleton-like frame integrally joined to the outer surfaces of left and right side walls of the cylinder barrel assembly block along the axis of a crankshaft, and a plate-like rigid film member provided integral with the outer surface of the skeleton-like frame, said skeleton-like frame comprising a plurality of crossbeam bone members, longitudinal beam bone members and post bone members which have rigidity and are unitarily assembled into a three-dimensional latticework structure.

7. An engine block according to claim 6, wherein said cylinder barrel assembly block is formed with a coolant jacket so as to surround the cylinder bores of the cylinder barrels.

8. An engine block according to claim 6, wherein said plurality of crossbeam bone members extend laterally and outwardly at intervals in the direction of the crankshaft axis and the cylinder bore axis from the outer surfaces of the left and right side walls of the cylinder barrel assembly block, said plurality of longitudinal beam bone members extend in the arranging direction of the cylinder barrels spaced apart from each other in the direction of the cylinder bore axis and integrally joining said crossbeam bone members in the direction of the crankshaft axis, and said plurality of post bone members vertically extend in largely spaced apart from each other in the direction of the crankshaft axis and integrally join the crossbeam bone members in the direction of the cylinder bore axis.

9. An engine block according to claim 6, wherein said plate-like rigid film members are directly adhered by adhesives to both the left and right outer surfaces of the skeleton-like frame of three-dimensional latticework structure.

10. An engine block according to claim 6, wherein said plurality of crossbeam bone members and post bone members are positioned on the extension of both end walls in the direction of the crankshaft axis of the cylinder barrel assembly block of the cylinder barrel assembly block and adjacent boundary walls of the adjacent cylinder bores, and an upper half portion of bearing for supporting an upper half portion of the crannkshaft is provided under the projection surface of the crossbeam bone members and post bone members.

11. An engine block according to claim 6, wherein the outer surface of said skeleton-like frame is formed linearly substantially parallel with the cylinder bore axis of the cylinder barrel assembly block, and said plate-like rigid film member is provided integral with the outer surface thereof.

12. An engine block according to claim 9, wherein said left and right rigid film members joined to the left and right outer surfaces of the skeleton-like frame are respectively formed from a single member.

13. An engine block having a cylinder block, a cylinder head integrally superposed and coupled onto a deck surface thereof and a lower case integrally joined to the lower surface of said cylinder block, said cylinder block comprising a cylinder barrel assembly block provided with a plurality of cylinder barrels each having a cylinder bore, a skeleton-like frame of a three-dimensional latticework structure integrally coupled to the outer surfaces of the left and right side walls along the crankshaft axis of the cylinder barrel assembly

block, and plate-like rigid film members provided integral with the left and right outer surfaces of the skeleton-like frame, the left and right outer surfaces of the cylinder block and the lower case along the crankshaft axis being formed flush with substantially parallel with the cylinder bore axis.

14. An engine block according to claim 13, wherein the outer surfaces of said cylinder block and said lower case along the crankcase axis are formed flush linearly in the direction of the cylinder bore axis, and the left and right outer surfaces of the cylinder head along the crankshaft aixs are within an imaginary extended surface passing through the outer surface of the cylinder block in the same direction.

15. An engine block according to claim 14, wherein said cylinder block and said lower case are of a generally rectangular parallelopiped integral structure.

16. An engine block according to claim 13, wherein said lower case comprises a lower case frame composed a frame body of a three-dimensional latticework structure, and second plate-like rigid film members integrally disposed at least on the lateral outer surfaces of the lower case frame along the crankshaft axis.

17. An engine block comprising a lower case integrally joined to the lower surface of a cylinder block having cylinder barrels having a piston slidably fitted therein, and a crankshaft connected to said piston and rotatably supported between said joined surfaces, said lower case comprising a lower case frame of three-dimensional latticework structure and second rigid film members disposed at least on the lateral outer surfaces of the lower case frame along the crankshaft aixs, said lower case frame comprising a plurality of crossbeam bone members having a bearing cap portion of a crankshaft in the central portion thereof and laterally extending in a direction of substantially perpendicularly intersecting the crankshaft axis, a plurality of longitudinal beam bone members for integrally connecting outer ends of said crossbeam bone members along the crankshaft axis, and a plurality of post bone members for integrally connecting outer ends of said crossbeam bone members in a direction of the stroke of said piston, said longitudinal beam bone members and said post bone members having said second rigid film members provided on the outer surfaces thereof.

18. An engine block according to claim 17, wherein said lower case frame and said second rigid film members are formed of different materials, and said second rigid film members are joined to the outer surfaces of said longitudinal beam bone members and said post bone members of the lower case frame.

19. An engine block according to claim 18, wherein said joining comprises adhering.

20. An engine block according to claim 17, wherein said lower case frame and said second rigid film members are integrally formed.

21. An engine block according to claim 17, 18, 19 or 20, wherein a bottom plate bored with an oil return hole is coupled to the lower surface of said lower case.

22. An engine block according to claim 21, wherein the lower surface of said lower case is covered with an oil pan, said oil pan together with the lower case being tightened and secured to the cylinder block by a plurality of oil pan-mounting bolts.

23. An engine block comprising a lower case joined to the lower surface of a cylinder block and a crankshaft rotatably supported between said joined surfaces, wherein said lower case is tightened and secured to the lower surface of said cylinder block by a plurality of oil pan-mounting bolts, and an oil pan is floatingly carried on the lower surface of the lower case via resilient members.

24. An engine block comprising a cylinder block which constitutes a main part of an engine block, said cylinder block comprising a cylinder barrel assembly block provided with a plurality of cylinder barrels each having a cylinder bore, a skeleton-like frame of a three-dimensional latticework structure integrally joined to the outer surfaces of left and right side walls of the cylinder barrel assembly block along the axis of a crankshaft, and a plate-like rigid film member integrally provided on the outer surface of said skeleton-like frame, said cylinder block having a square-shaped transmission mating surface on the cylider block side on one end surface along the axis of a crankshaft, the right and left surfaces along the cranshaft axis thereof being linear along the cylinder bore axis, and comprising a divergent bulged portion which extends from a rear part of the cylinder block in a fan-shape toward the transmission mating surface.

25. An engine block according to claim 24, wherein a lower case is integrally joined to the lower surface of said cylinder block.

26. An engine block according to claim 25, wherein a transmission mating surface on the lower case side flush with a transmission mating surface onthe cylinder block side of the cylinder block is formed on one end surface of the lower case along the crankshaft axis, left and right side surfaces along the crankshaft axis are linear in the direction of the cylinder bore aixs, the lower case further has a divergent bulged portion which extends from a rear part thereof in a fan-shape toward the transmission mating surface on the lower case side, and a square-shaped transmission mating surface is

formed by the transmission mating surfaces on the cylinder block and lower case sides.

27. An engine block according to claim 26, wherein bolt-inserting bosses are provided at four corners of the transmission mating surface to couple a transmission case of the transmission.

28. An engine block according to claim 25, wherein said bulged portion has bone members comprising a frame in the form of a triangle post and said rigid film member joined to the inclined outer surface of said frame.

FIG.1

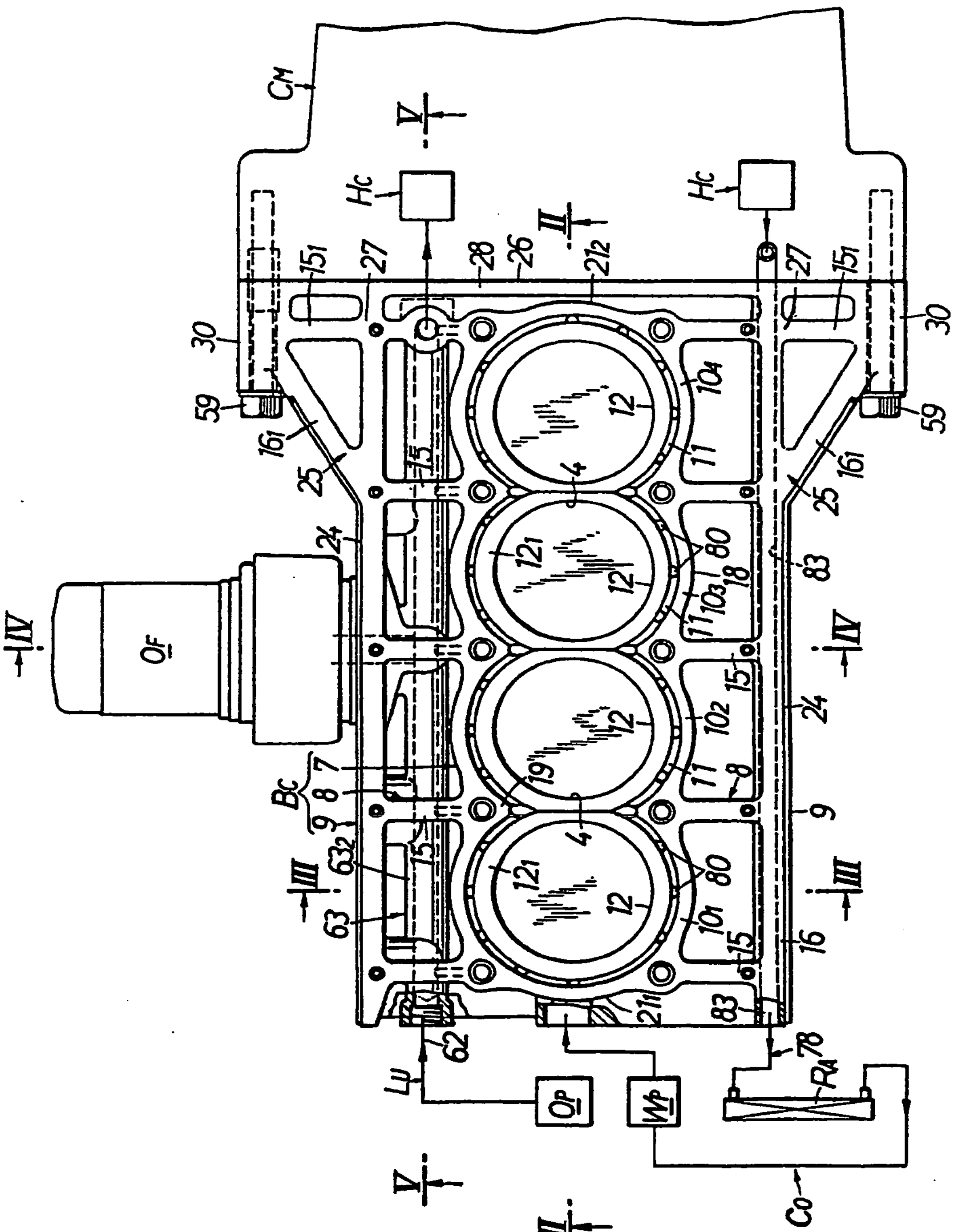


FIG.2

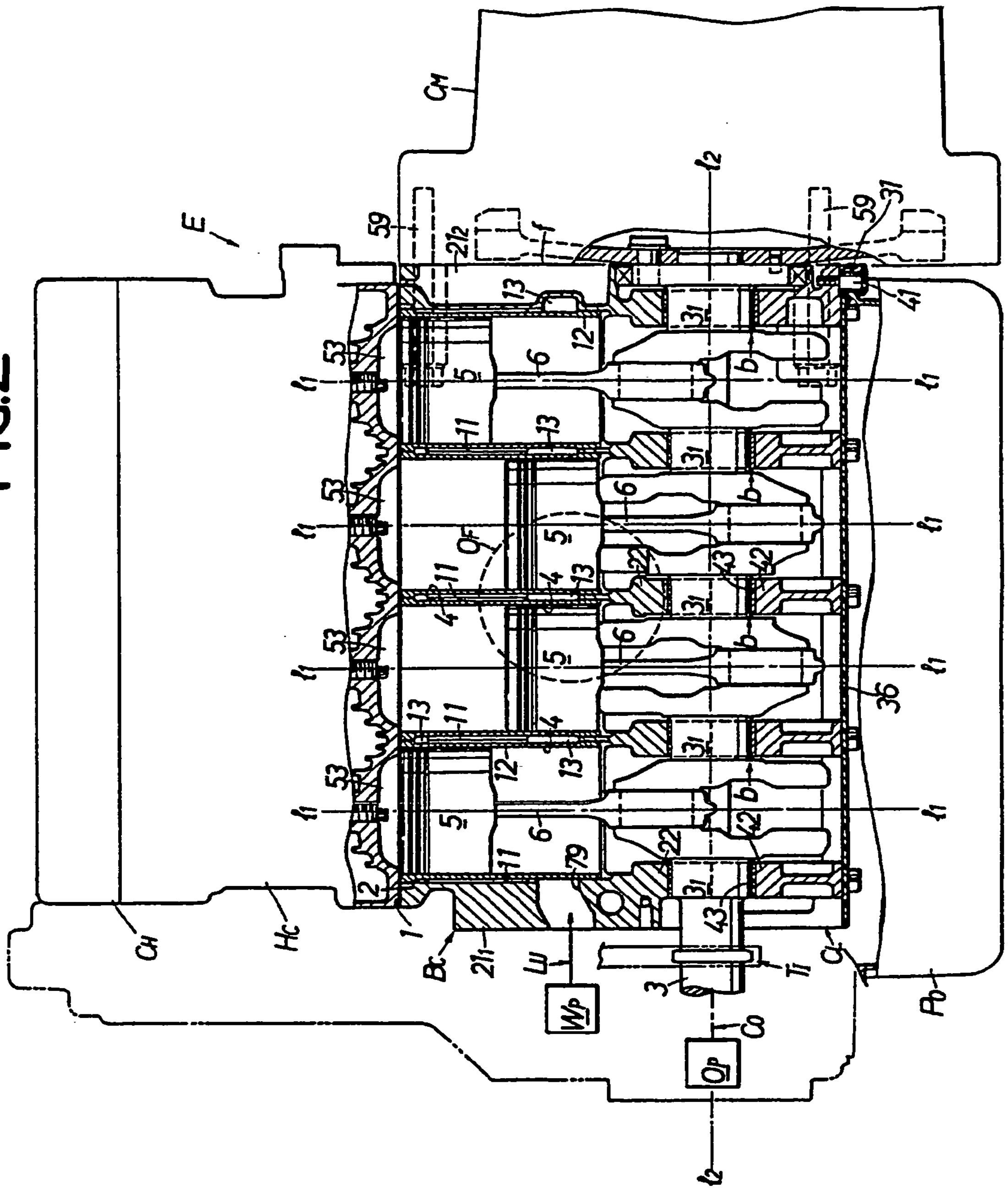

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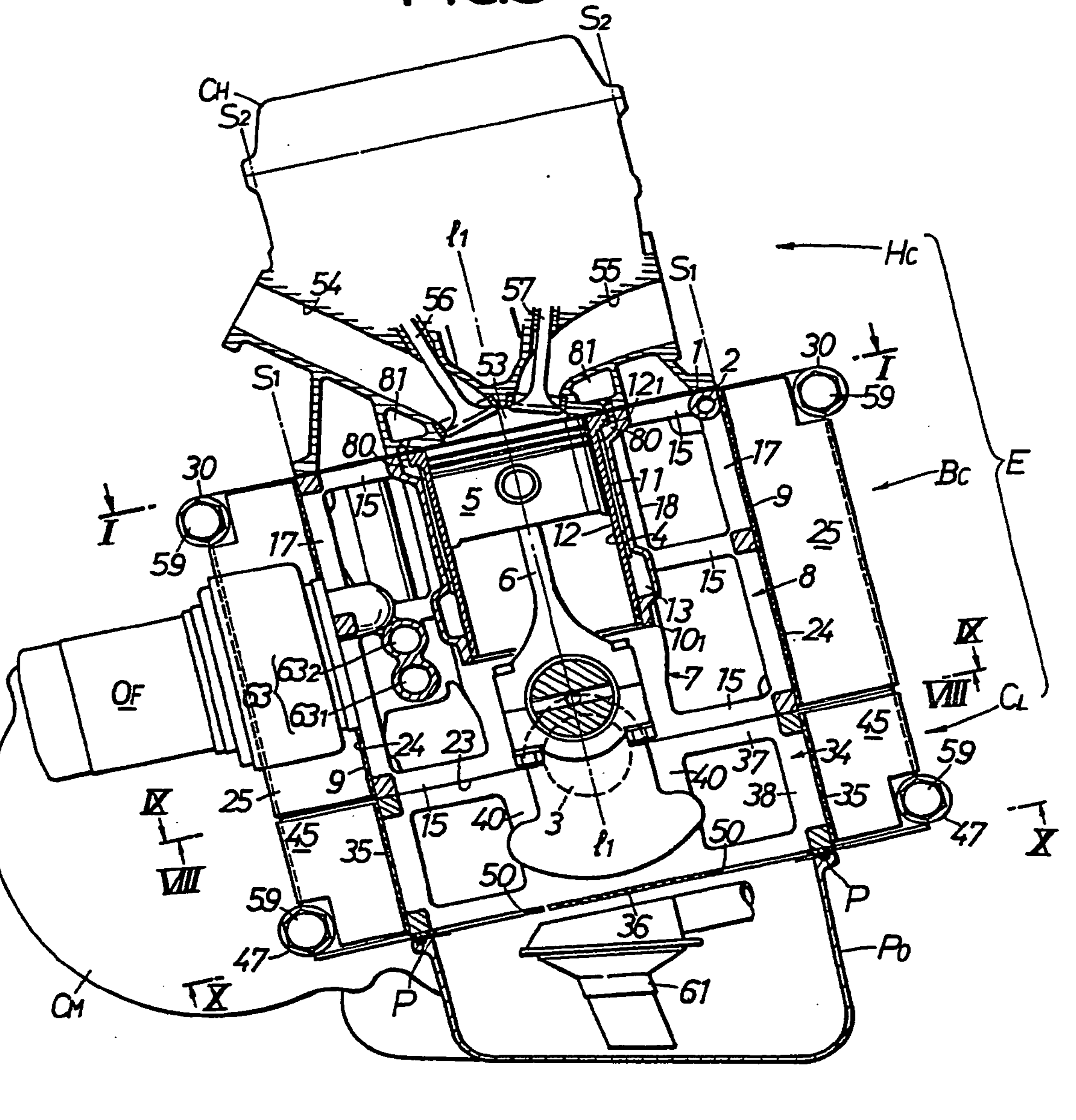
FIG.3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8
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101
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IX
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631
7
15
VIII
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FIG.4

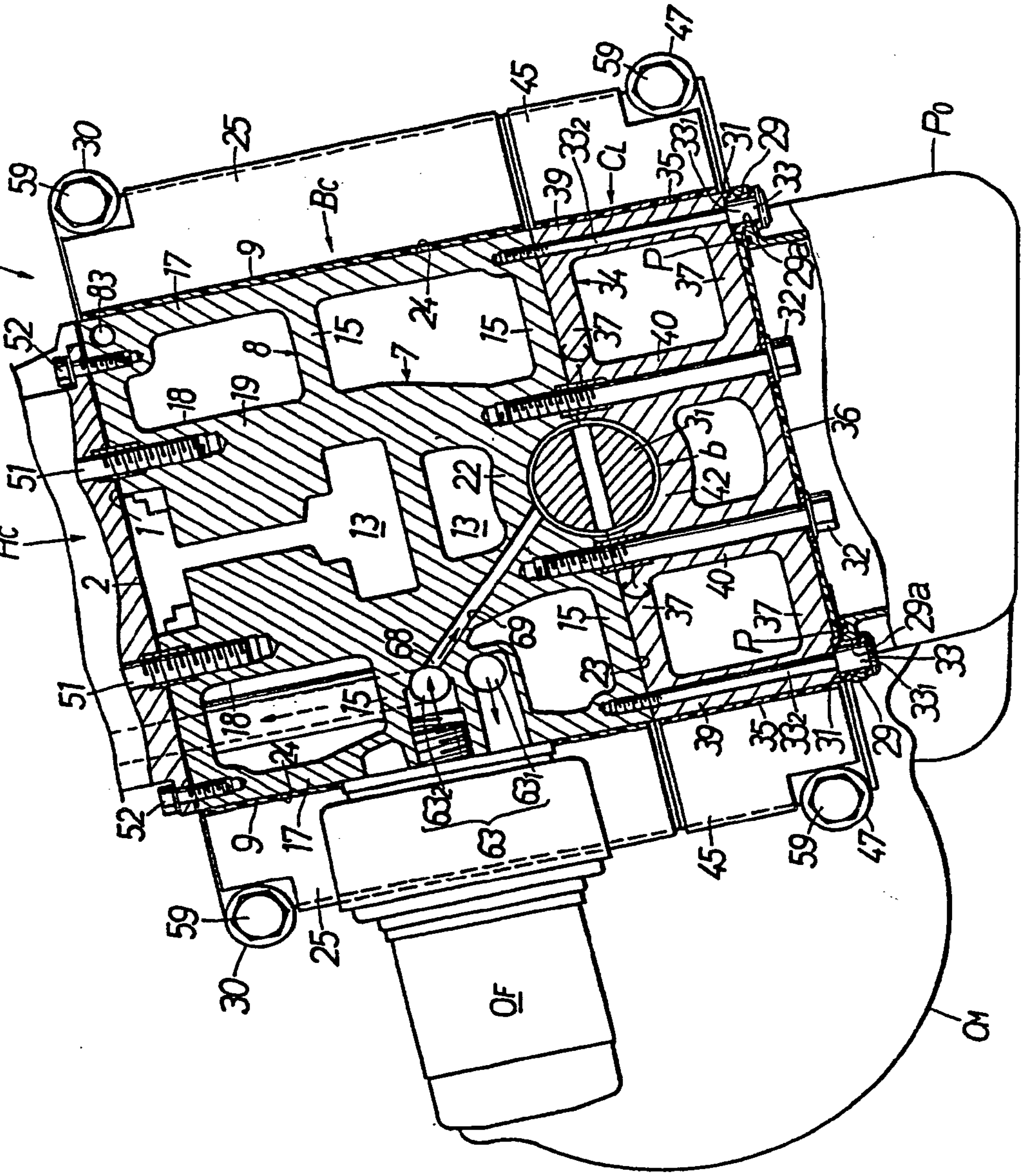
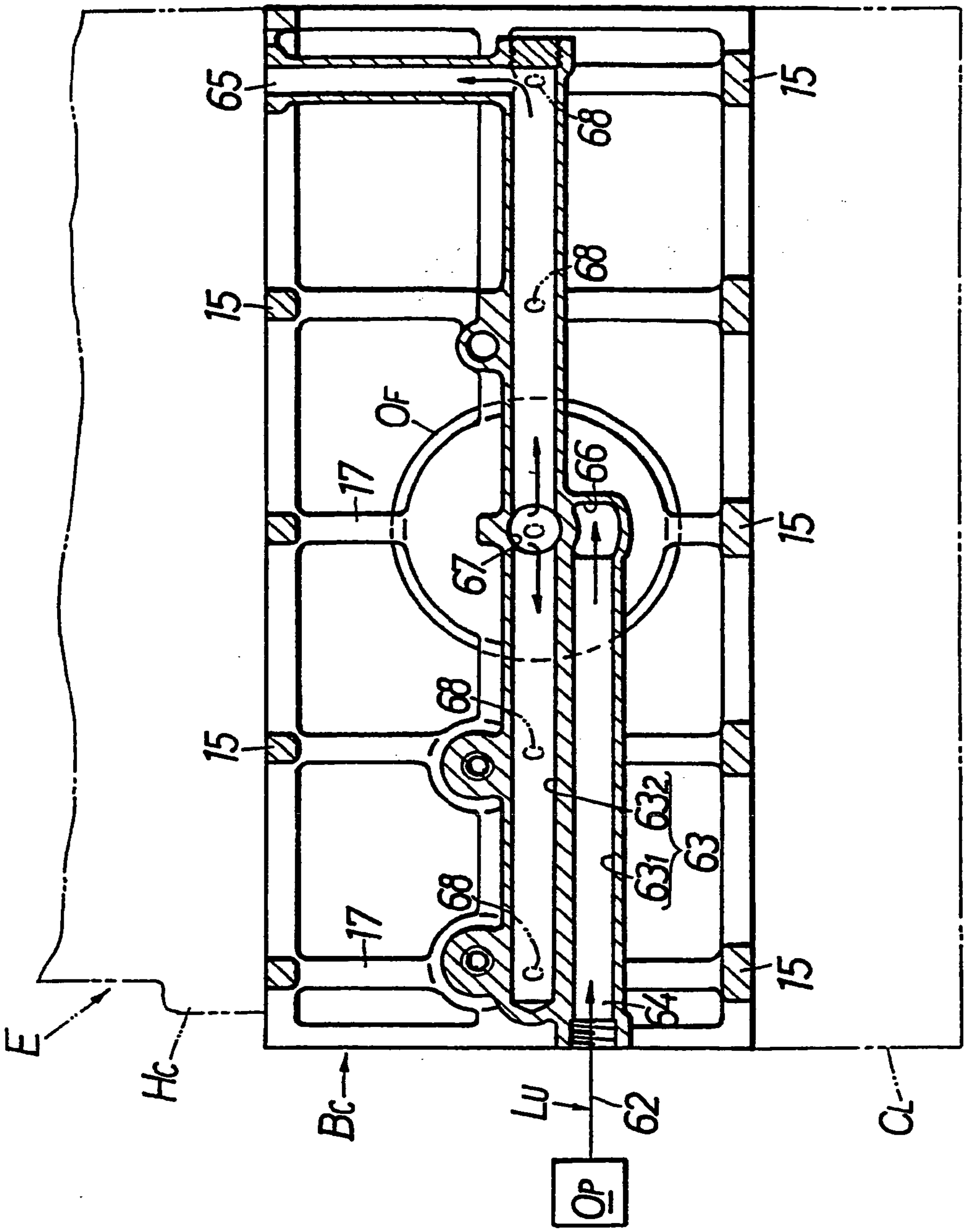


FIG.5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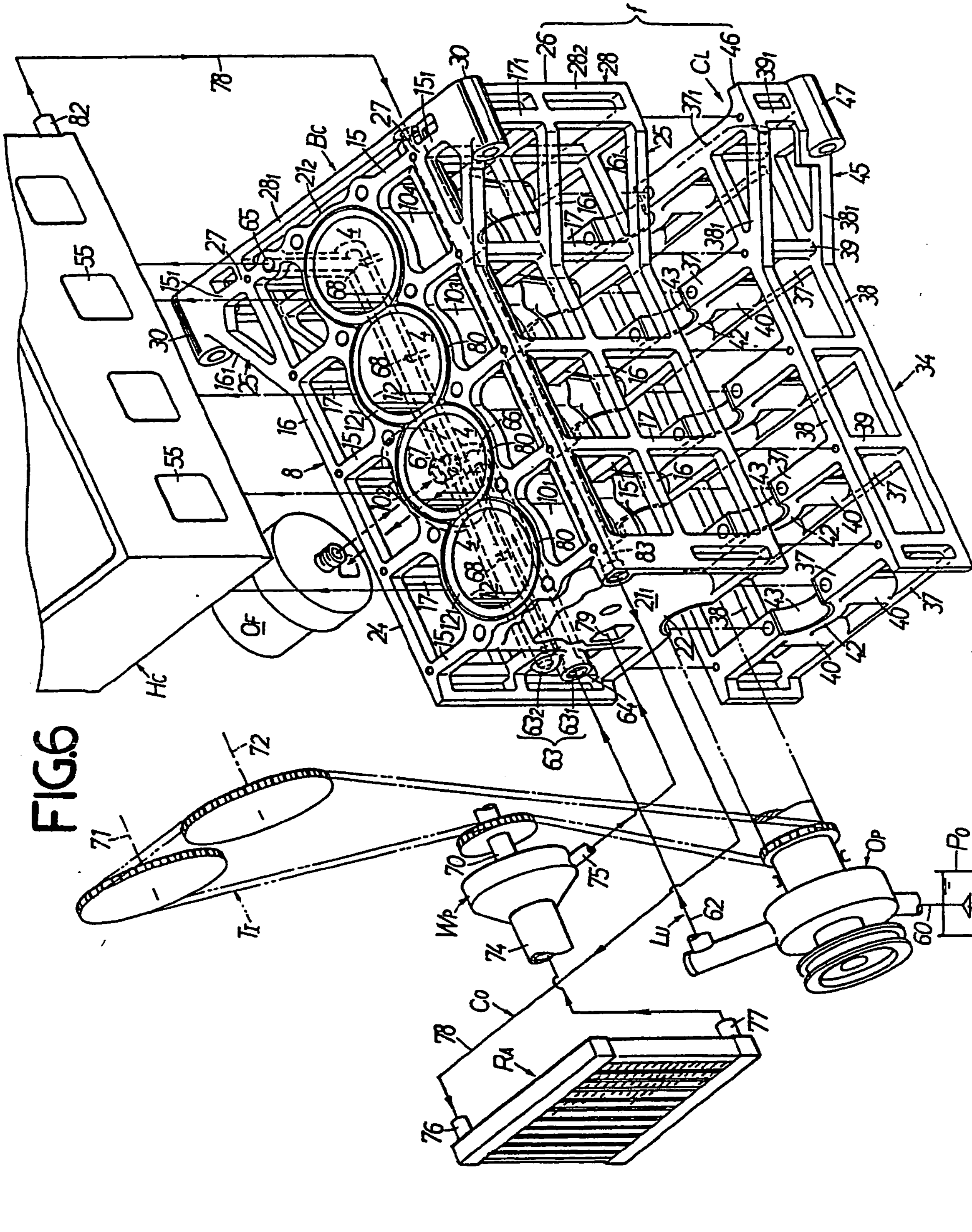


FIG.6

FIG.7

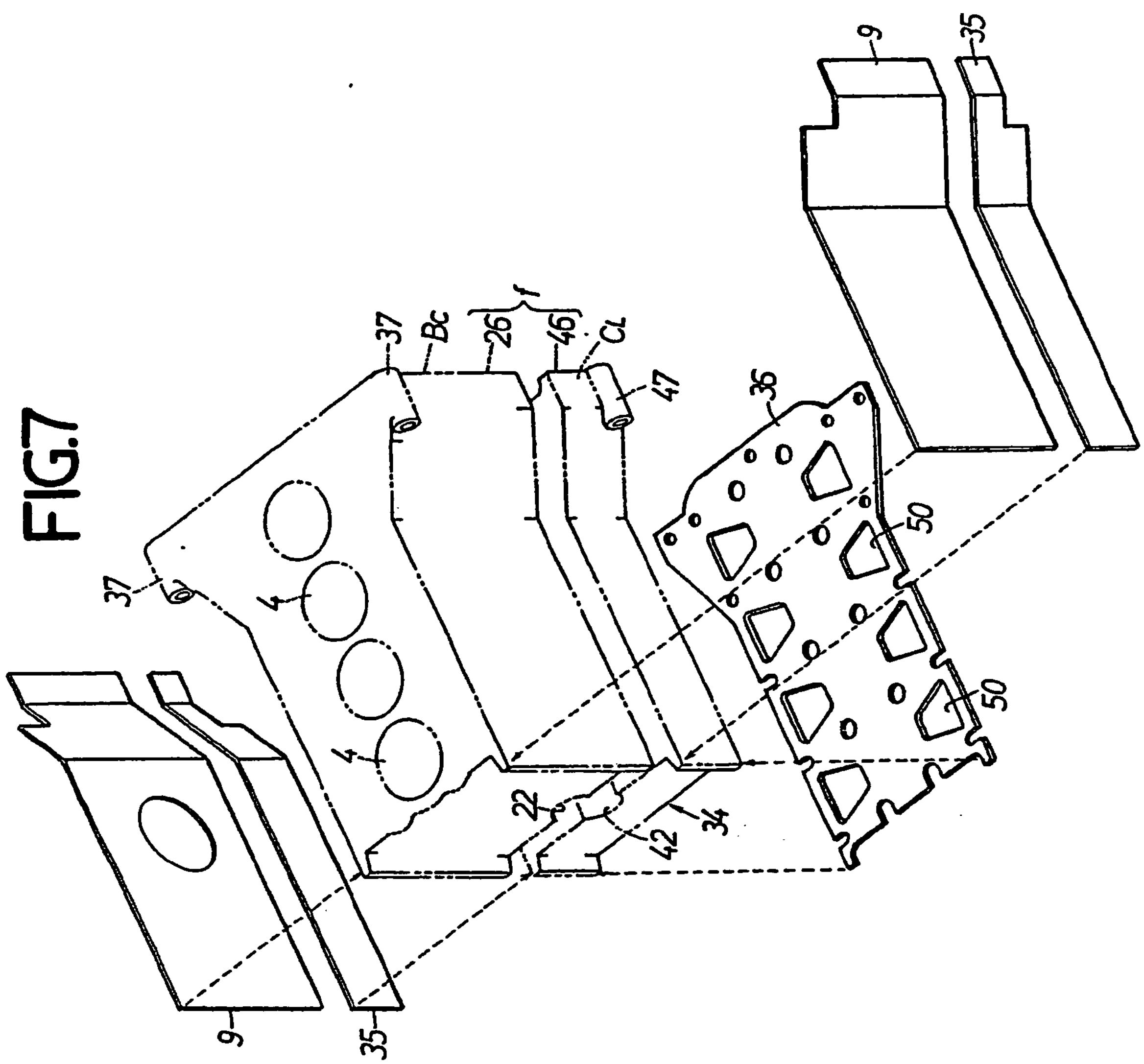
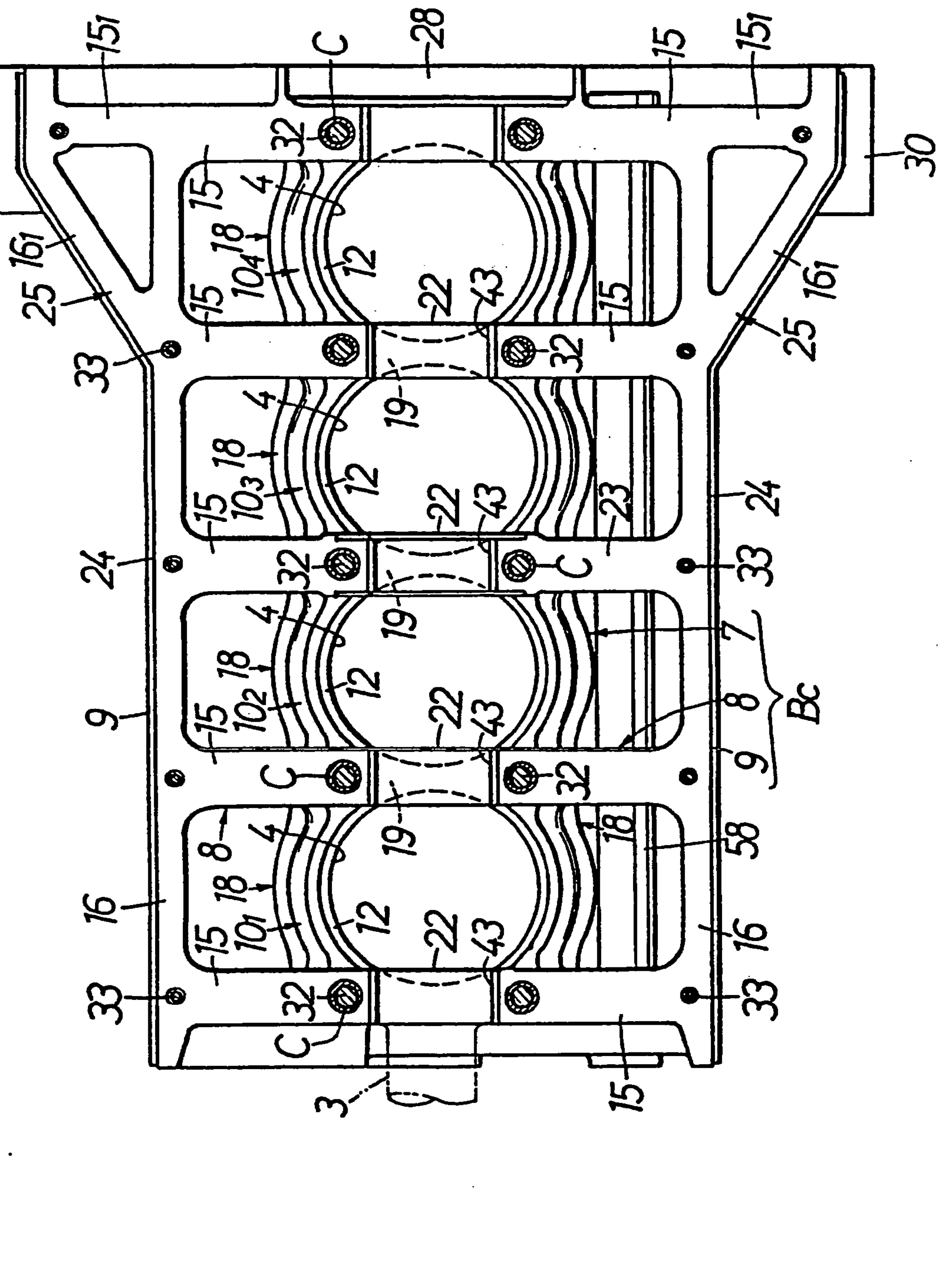


FIG.8



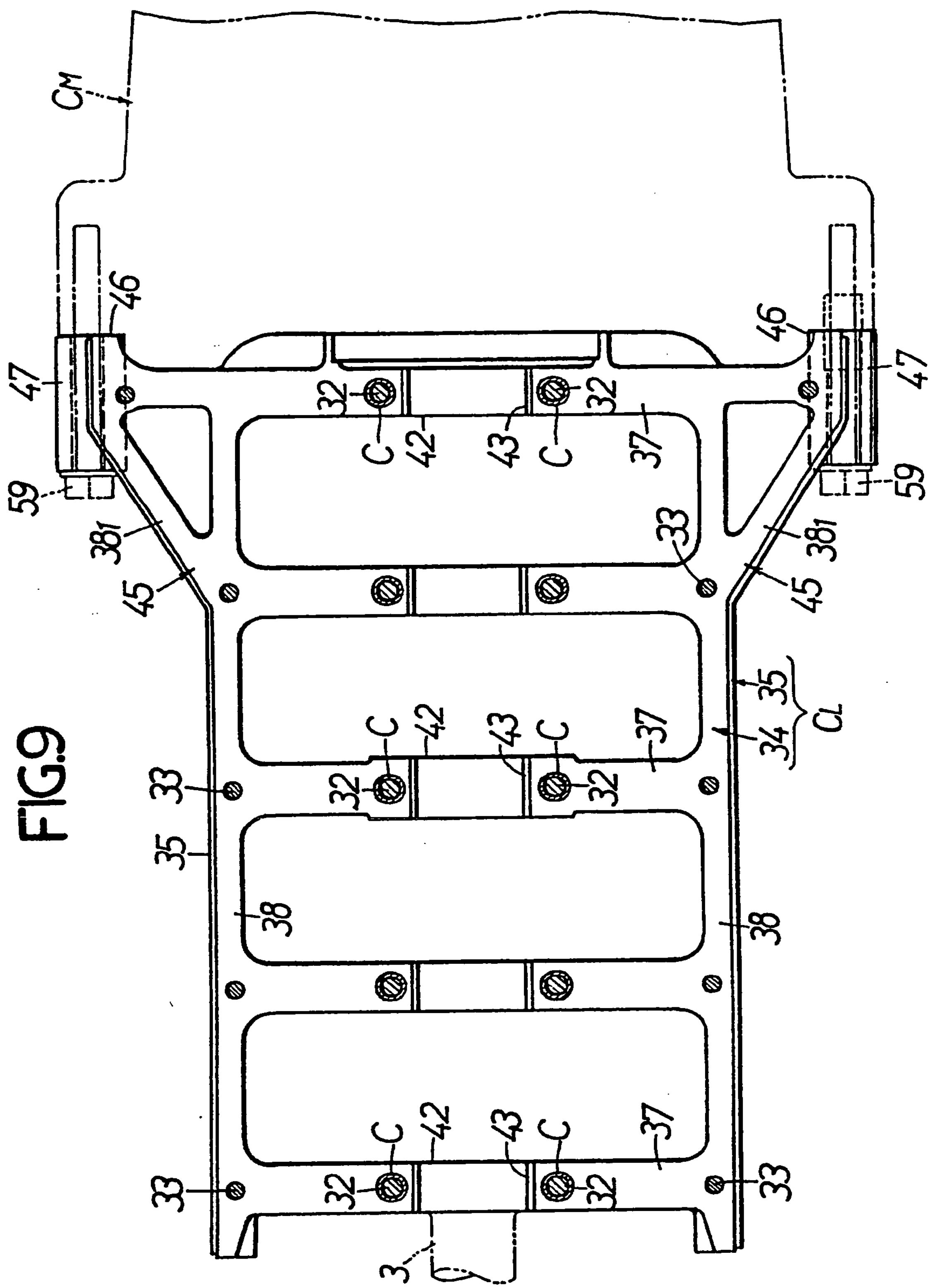


FIG.9

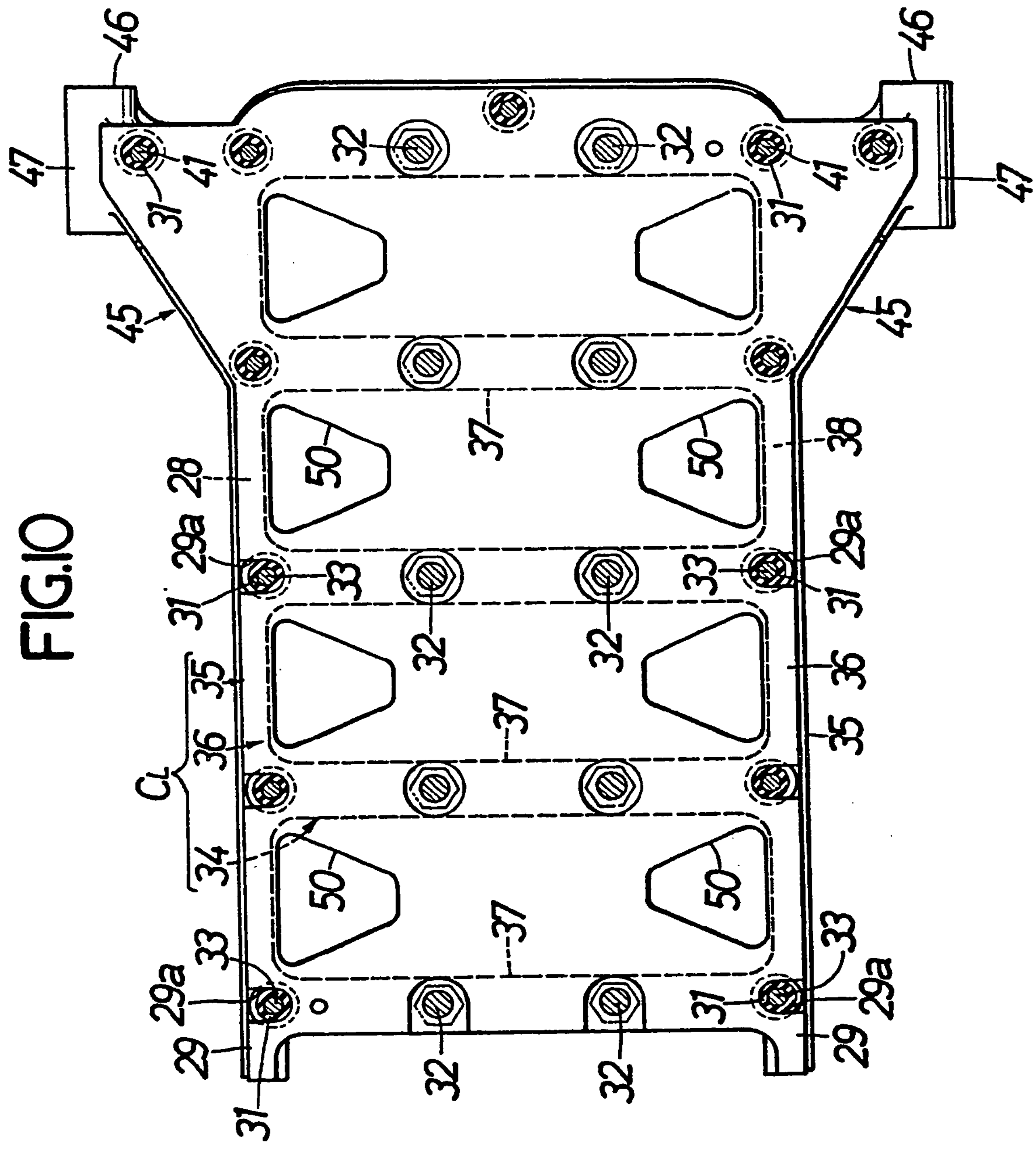


FIG.10

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 89 31 0416

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y	EP-A-0 067 890 (NISSAN) * The whole document *	1,6,7,9,10,11,13	F 02 F 7/00 F 02 B 75/20
A		12,15,17,22	
D,Y	US-A-4 753 201 (HONDA) * Abstract; column 5, lines 28-52; figures 4,7 *	1	
Y	GB-A-2 147 662 (HONDA) * The whole document *	1,6,7,9,10,11,13	
A		8,12,15,17,19,22	
A	EP-A-0 038 560 (NISSAN) * The whole document *	1,4,6,7,17	
A	PATENT ABSTRACTS OF JAPAN, vol. 8, no. 83 (M-290)[1520], 17th April 1984; & JP-A-59 552 (NISSAN) 23-06-1982 * The whole document *	1,4,5,13	TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			F 02 F F 02 B
A	US-A-4 369 744 (NISSAN) * The whole document *	17,24	
A	FR-A-2 431 651 (BERLIET) * Figures 1,2 *	23	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	15-02-1990	MOUTON J.M.M.P.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

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